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Enhancement of energy conservation technologies in wireless sensor network

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Abstract

In the last few years, wireless sensor networks (WSNs) have been widely used for many applications in both profitable and non-profitable organizations. As sensor nodes used in most of the applications are generally battery-powered devices, the challenges focus on how to increase the lifetime of each sensor node and how to reduce the energy consumption of each node, so that the network energy efficiency (EE) can be maintained to deliver the data for a reasonable time. In this paper, we analyze to enhance the energy conservation approach which reduces the energy consumption, cost and complexity. In this research, combination of routing and solar power is analyzed as enhancement of energy conservation technology (EECT) which increases the lifetime of the sensor node as well as the battery. Even though, solar power concept is not new for the WSN, EECT can be used for where some selected applications such as monitoring air condition in large organizations are directly involved with the sun light and heat.

Selection and peer-review under responsibility of Conference Program Chairs

Keywords: wireless sensor network; solar power; energy efficiency; EECT

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1. Introduction

The necessity and trends of EECT can be obtained from many sources which are direct heat from the Sun, waste heat from human, factories and vehicles, etc. Utilizing waste heat energy from human can be used for WSN where sensor nodes are in micro or nano scale which consumes and uses very little energy. These tiny sensors may be used for human monitoring with low-cost and finding symptoms of some diseases without any side effects. Waste heat from factories was investigated to generate the electrical energy through EECT but it could be used for charging batteries employed in WSN. Direct heat from the Sun is wasted in hot countries where maximum energy can be saved for many applications including WSN. According to[25], solar energy and its advantages and energy-aware routing concept which includes routing algorithms for WSN are considered with practical approaches.

1.1. Our contributions

In this paper, we discuss some procedures based on EECT that help us to maintain the WSN with low-cost and energy efficient algorithms. Here, we analyze how much heat is wasted in each second and how we can use these opportunities to transfer the WSN through EECT. In this study, saving energy in large scale is considered with theoretical analysis, which provides us to implement a real system.

Heat is wasted in many ways and it destroys the natural environments with high pollutions. When WSN is systematically applied, following advantages may be useful to environment they are energy saving with low-cost, increasing EE in WSN, maintaining pollution free zone, etc.

Heat energy in hot countries can be transferred to different energy that is useful for necessary systems used in our real life. It will not only generate the energy but it also provides a clean environment around the residential area.

1.2. Taxonomy of EECT based routing protocols in WSN

In WSN, taxonomies of routing protocols are identified for many cases that may be categorized according to the applications and environmental conditions[1,2]. For instance, energy saving procedure of data driven approaches is mentioned as shown in Fig. 1.

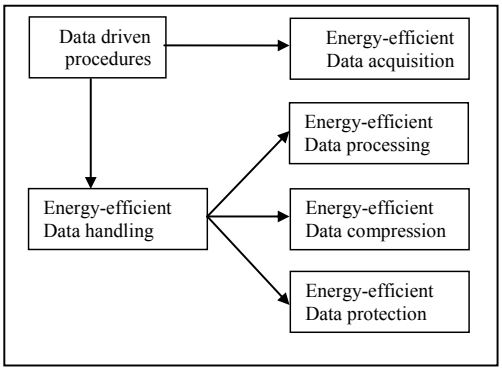

Fig. 1. Taxonomy of data driven procedure (Example of EECT)

To analyze the basis of EECT developed for routing protocols, EECT based routing protocols in WSN can be classified into many categories[3]. They are ant colony optimization (ACO) based routing protocols, Equalized Cluster Head Election Routing Protocol (ECHERP), Low-Energy Adaptive Clustering Hierarchy (LEACH) etc. To maintain the EECT, energy efficient and load balancing routing concept[7] is used in WSNs. These protocols and their design concepts are different because they are developed for different applications where we can consider EECT. Geographic Routing with Environmental Energy Supply (GREES)[14] is an algorithm that functions according to the

environmental conditions. This protocol helps us to design a new protocol based on heat energy, which is the another taxonomy of EECT based routing protocol in WSN. Distributed energy-efficient clustering with improved coverage (DEECIC) uses energy to controls the messages within the WSN.

The rest of the paper is organized as follows. Sections 2 and 3 discuss representative routing protocols based on energy efficient algorithms which may be involved with heat energy directly or indirectly. Section 4 analyzes the performance of these routing algorithms in terms of selected definitions that support the lifetime of WSN. Finally, Section 5 concludes the paper and further points out the open research problems.

2. Related work

Early work of energy saving protocols[17] in the wireless network has been investigated and also it is extended to WSN with EECT. In order to introduce some energy saving protocols based on solar heat, relevant related works are considered with solar heat[4,5]. According to the recent survey[1,3], many EE algorithms and protocols are available but they had been using some selected parameters such as delay, traffic and design. Energy source such as battery cannot be used to maintain energy for a lifetime in WSN[20].

2.1. Energy consumption

Minimum energy consumption, low-heat during the processing and long lifetime with low-cost technology are considered in the design of energy efficient protocol used in WSN. According to the 3D concepts in WSN[22-24], finding average distance of active nodes at the time would be very useful to save the energy consumption in real applications. As given in (1), distance between the active sensor nodes, which release the heat and non-active nodes, which may or may not release the heat should be calculated accurately according to 3D concepts.

$$d = T(x, y, z) \tag{1}$$

Here, T(x, y, z) is the heat distribution[21] in Cartesian coordinates that help us to find the exact location of active sensor nodes with environmental conditions. In (1), x, y and z are the co-ordinates, which help us to find the exact location of the node used in 3D topology.

2.2. Computational technology of heat energy

There are many topologies available for some specific applications but fixed topologies are used in most of clusters employed in specific application[18]. Computational technology (CT) of different topologies is very useful to monitor the wasted heat and energy saving expected from delay, traffic and processing[16,19]. Here, CT is considered with heat that is one of the future challenges in WSN and its applications. In order to explain the concept of CT, Fig. 2 can be illustrated for 3D WSN. In medical applications, some sensor nodes are activated with the temperature of the body, hence limitations of heat in sensor devices can be calculated using CT and apply as renewable energy.

Further, necessary calculations of renewable energy system using CT depend on the architecture that is a topology where sensor nodes are located as shown in Fig. 2. Distance between the nodes and temperature of each node can be used in path selection procedures[6] considered within the routing protocols. In EECT, consumption of energy in each device of WSN should be minimized using correct protocols influenced with heat. In generally speaking, 50 to 50000 sensor nodes can be used within selected area such as an urban area (more nodes within a fixed area) and remote area (fewer nodes a within fixed area).

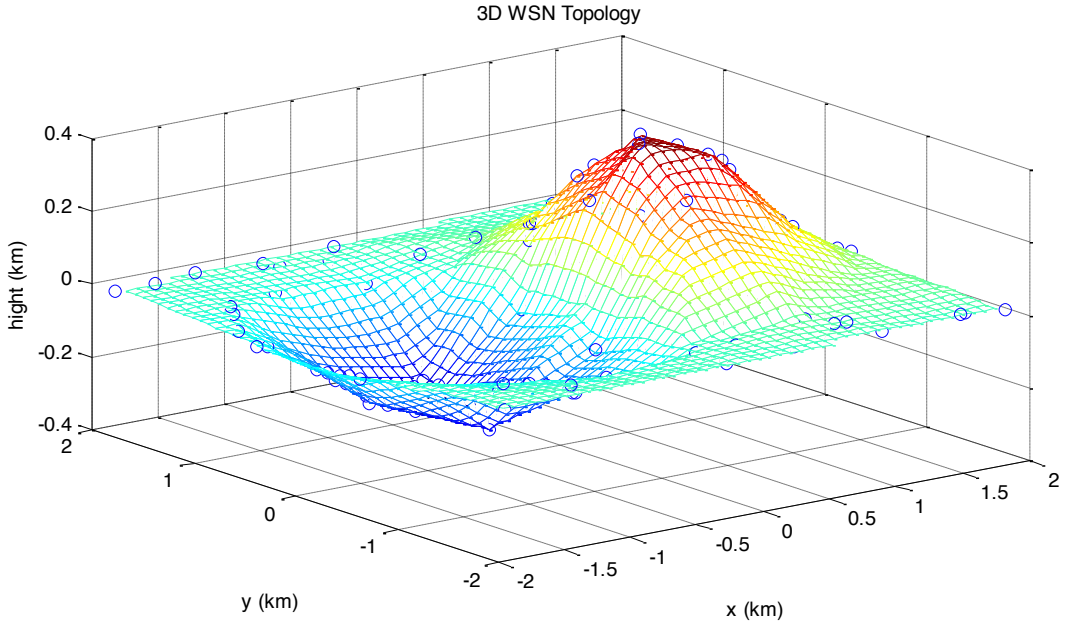

Fig. 2. Topology for selected area

There are many energy conversation schemes (ECS) used in wireless networks that include wireless sensor and mesh networks. Even though many energy efficient protocols are used in WSN, some protocols are easily modified to absorb heat from each sensor nodes. As shown in the Table1, some selected protocols used for ECS are illustrated with some necessary action. Following information can be used for developing EECT in each layer where suitable algorithm can be employed according to the future developments.

Table 1. Energy conservation schemes for WSN

Energy conversation schemes	**Necessary action**	**Focused Network layers**	**Algorithms**
SWAP	Energy efficient data Acquisition with adaptive sampling	Physical layer	Receiver
LEACH	Contention based MAC protocol	Data link layer	ACO
DEECIC	Energy efficient data acquisition with clustering	Network layer	ACO

All layers are depending on the previous layers' services and physical layer which is the first layer uses many receiver algorithms can be modified for EECT. In the physical layer, Sampling Workload Allocation Problem (SWAP) is identified to improve the energy using appropriate receiver algorithm. The EECT model includes the five states: Energy efficient data acquisition, Low power transmission, Low complex reception, Listen and Sleep[11,15].

2.3. Routing strategy based on EECT

In the routing strategy, global transmission of all nodes cannot be expected in WSN but individual transmission is expected with dynamic search when absolute communication is necessary. According to the multi hop[8] technique, enhancement of energy conservation can be achieved when an energy-efficient routing algorithm[9] is used for data gathering in WSN. Using ACO[10-13], EEABR (Energy-efficient ant based routing), ACORC (ant colony optimization router chip), etc. can be used to build a routing strategy based on EECT that influences with heat. The ACO concept for finding the shortest path[6] between the source and destination is studied for developing a protocol based on heat energy. For instance, the routing protocol such as AODV can be modified with solar powered battery [25]and ACO when it is employed in the WSN. Few of energy efficient protocols are modifiable with the intelligent approach they are such as LEACH and GREES. Some of the routing protocols are designed for different purposes which take more energy. They are such as adaptive tree protocol (ATP) and generic algorithm (GA)[3] assumed as less or non energy efficient protocols.

3. Proposed scheme

In this scheme, sensors employed in WSN should be organized some free places where each sensor node should be able to absorb the heat from solar energy. In WSN, the initial energy should be maintained properly during the transmission that may be between the sensor nodes or transmitting and receiving node. Otherwise data or packet delivery during the transmission processing is delayed or dropped. So, options are limited to this research because we need to choose the places where direct sun lights are available. If this option is not suitable, orbiting earth satellite can be modified to create a solar energy where necessarily.

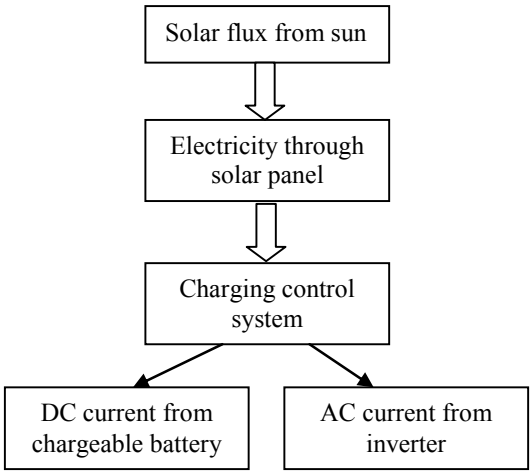

Fig.3 Solar energy creation of EECT for WSN

The methods in which energy savings can be modified with following ways:
1. Devices used in WSN: Hardware components in each device selection and their configuration should be set to achieve low energy consumption or to keep within low temperature.
2. Network topology in WSN: Choice of interfaces, communication methods and protocols should be set to minimize energy consumption.

As shown in Fig. 3, necessary energy for each node can be generated from the solar source, which stores the solar energy. Photovoltaic (PV) elements and right choice of necessary material included within the solar source are used in equation (2).

$$E_{sol} = Ak_{sol}E \tag{2}$$

Where, E_{sol} is energy generated per day, A is area of solar panels, k_{sol} is the energy constant of the solar source which may be a solar panel and E is the expose of the sunlight or watts/m^2 x (hours of sunlight)

In devices, prism can be used as an EECT because seven different colours which hold different energy are very useful to provide necessary energy WSN. Here, different photon energy is released from each colour but blue colour provides more energy than any other colours.

$$E_2 - E_1 = hf \tag{3}$$

In equation 3, h is considered as Planck constant, $E_2 - E_1$ is the energy difference of a photon and f is the frequency of its waves associated with solar heat. The EECT can be developed using solar heat that is freely available energy to renew the energy sources used WSN. Hybrid system that provides heat and electricity storage from the solar energy is another EECT and sustainable energy technology and application.

$$E_a = \frac{\sum_{i=1}^{n} i}{n} \tag{4}$$

Average energy E_a can be defined as in (4) where i is the energy consumed by the i-th node and n is the total number of nodes deployed within the WSN topology.

4. Results and analysis

There are many routing protocols and algorithms available to improve the EE in WSN when sensors are deployed in a different topology developed for individual applications. As shown in Fig. 4, energy conservation schemes (ECS) and solar scheme are considered for the basic comparisons.

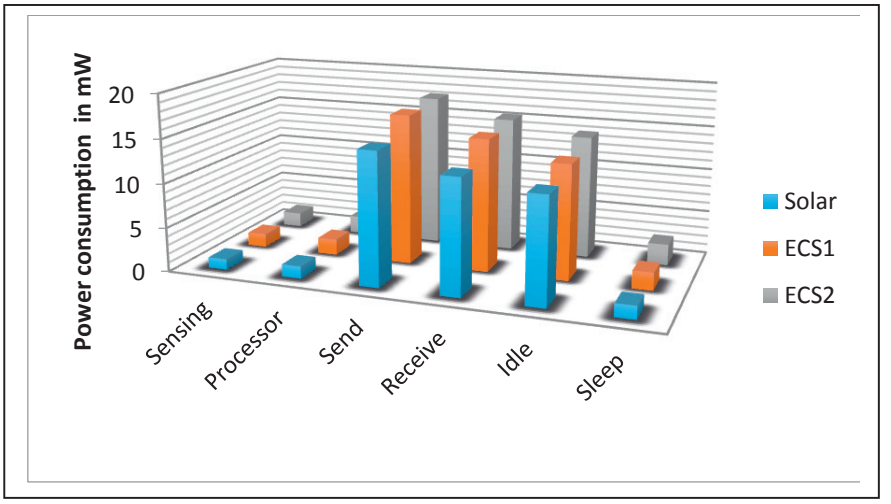

Fig. 4. Energy consumption of sensor used WSN

In ECS1 and ECS2, different protocols are used to compare the results that are average values of energy efficient protocols and non energy efficient protocols respectively. Examples of ECS1 (energy efficient protocols) and ECS2 (less or non energy efficient protocols) are mentioned in sub-section 2.3. Even though all results are almost same, cost of the solar schemes is much cheaper than other schemes. Energy from the heat compensates some part of the processing such us path selections and sensing when routing protocol based on solar scheme is designed for WSN. There are some advantages and disadvantages when we use the solar schemes. Main advantage is the design of efficient and intelligent routing protocol with renewable and storage energy facilities.

5. Conclusions

Energy conservation using heat is explored to utilize in WSN applications. In this study, EECT can be used to improve the energy efficiency in some applications that are dealing with heat conversion and transfer processing.

Many hot countries can transfer the heat energy to a different form which is applicable to their practical problems such charging mobile devices. It is very simple because many mobile devices are charged wirelessly and stored for next few hours which may be extended with appropriate materials. The topology of existing WSN and three dimensional WSN have been studied for EE analysis.

Waste heat from WSN devices can be reused or employed to solve some routing problems such as identifying path and optimization. Heat energy not only reduces the cost of energy but also it protects the internal components of the devices used in the WSN.

In the future, energy-efficient routing protocols can be developed using waste heat released from all devices integrated with WSN.

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